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A SCIENTIFIC SATELLITE PROGRAM

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A SCIENTIFIC SATELLITE PROGRAM

This is a proposal for an earth satellite program. It proposes (1) a useful purpose for the satellite, (2) a method of achieving that purpose, and (3) an organization capable of implementing the method.

Purpose

The most useful function that can be served by the first artificial satellite lies in the field of geodesy. The United States has been and is now expending considerable effort and funds to refine geodetic measurements. One of the most difficult geodetic tasks involves tying together the various continental grids and locating the many islands with respect to these grids. Whereas it is possible to map entire continents by well-known methods of triangulation, the technique fails when it must be extended across large bodies of water. As a result, geodesists have turned to other methods which are, in general, based on the use of the only presently available satellite, the moon, as a measuring vehicle. Both the Army Map Service and the Naval Observatory are active in the use of the moon as a reference body for geodetic and time measurements.

An artificial satellite, which would be small in size and mass, and at a short distance from the earth, would have numerous advantages over the moon (see Appendix A). The accuracy of measurement of geodetic constants could be improved about 10 times. Equally important - the small satellite technique would yield a large volume of geodetic data in a relatively short time. Improved geodetic data is required to provide maps of sufficient accuracy for locating potential military targets and Loran navigation stations.

Method

In order for a satellite to have geodetic use, it must be trackable with a high degree of precision. Although even a few accurately timed transits of the satellite will yield some data, the real geodetic meat will be derived from a large number of observations. Optical observation is recommended, but it has certain limitations. First, the orbiting object will be visible only for brief periods - at dawn or sunset, and when seeing conditions are good. Second, it will be exceedingly difficult to acquire the satellite in an optical instrument of sufficient power (and hence restricted field of view) unless there is previous precise knowledge of where the satellite will be. Indeed, it is readily conceivable that an object could be placed in an orbit and never observed, if only optical methods were used.

It appears highly desirable, therefore, to have some other method of observation. Such a method has been proposed by the Naval Research Laboratory (Appendix B). It depends upon radio interferometry and involves carrying a small transmitter in the satellite. The Laboratory has proven this technique experimentally in its ballistic missile research. It will provide precise observation of the satellite once every orbit at every station, day or night, fair weather or foul. The period of radio observation depends upon the lifetime of the transmitter (assuming a long-lived satellite) and could be weeks or months, if sufficient payload can be placed in the orbit. For a 10 lb payload the transmitter lifetime is about 5 weeks (using presently available equipment). A payload of 40 lbs would permit 4 months of operation. The great advantages of the radio tracker are (1) that

acquisition of the satellite is practically certain and (2) that the number of observations possible is an order of magnitude greater than for any optical tracker.

In view of the facts cited above, it is felt that the minimum payload the first satellite should carry is <u>10 pounds</u>. It would be highly desirable to choose a satellite system which can place as much as <u>40 pounds</u> into a stable orbit. This would permit radio tracking for long periods of time or alternatively, use of the satellite for geophysical measurements, i.e., the particle and ionic composition of inter-planetary space. The creation of an instrumented satellite has been recommended by the National Committee for the International Geophysical Year.

In selecting a vehicle to place the payload into an orbit, it is important to analyze the flight path and determine what factors are most critical, with a view toward alleviating any factor that requires a high degree of precision. It is generally agreed that the most critical factor in producing an orbit is the angular precision required in projecting the final stage. The required angular precision varies inversely with the altitude of projection. For instance, at 200 miles the tolerance is a fraction of a degree, and a very precise and complicated orienting mechanism is required. Above 300 miles the tolerance is several degrees permitting use of simple and more reliable orienting equipment. If the same equipment is used in both cases, the chance of obtaining an orbit is much greater at the higher altitude (Appendix D).

This proposal recommends use of a vehicle comprising the M-10 Viking and two solid propellant stages. (See Appendix C). This combination can

carry payloads ranging from 10 to 40 pounds into an orbit around the earth. For the lower payload the perigee is 334 miles, thus permitting a considerable tolerance on the angle of projection. The 40 pound payload would have a 223 mile perigee and hence would require more precise orientation equipment. Although a 10-lb satellite is considered sufficient initially for geodetic work, the particular vehicle was chosen with a regard to its growth potential - its ability to satisfy the International Geophysical Year requirement for an instrumented satellite in 1958.

The M-10 is a modification of the existing Viking which has exceeded 100 miles altitude in six flights and presently holds the altitude record for single stage rockets. Viking 4 was launched from a Naval vessel at sea to a record altitude for ship launched rockets. Viking offers the capability, which may have logistic advantages, of launching the satellite from a ship.

The M-10 modification has been studied for two years. Detailed design drawings have been prepared. No major functional change to the present Viking is envisioned.

The M-10 Viking has a 4-foot diameter, a length of 40 feet and a dry weight of 2250 pounds. It is readily transportable by motor vehicle, rail or air. It is actually the smallest available vehicle that could serve as a satellite first stage and, as such, will require a minimum of logistic support.

The solid propellant stages were designed by a reliable contractor to the Navy. The design has been checked by the Laboratory and is considered to be sufficiently conservative. There are many advantages, in addition to the apparent one of increased reliability, in using two rockets as opposed to a large number of small rockets in clusters.

The method proposed here would employ manpower and facilities not presently used in any operational military project.

In addition to providing payload flexibility, the proposed vehicle is capable of producing a variety of orbits. The equatorial orbit or one somewhat inclined (30° or less) to the equator is preferred (see Appendix D). But the vehicle is capable of producing a polar orbit (with a 10 lb payload), one that would traverse every location on the earth.

Time Scale and Cost

It is proposed to construct ten M-10 Vikings and a sufficient number of solid propellant stages for ground test and satellite use. Of the M-10's, three would be devoted to tests of the M-10 itself, leaving the remaining seven for satellite use.

On the basis of experience in Viking production, the first M-10 can be delivered in eighteen months. Succeeding M-10 vehicles can be delivered at a rate of one every six weeks. The period between 18 and 24 months would be devoted to firings of the M-10 alone, either at White Sands Proving Ground or the Air Force Missile Test Center.

The first satellite can be launched two years from the start of the program; the remaining satellite vehicles within the third year.

The lead time of two years prior to launching the first satellite provides sufficient time for production and test of the solid stages and assembly of radio and optical tracking equipment. Logistic planning would start at the outset of the program; logistic preparations should be completed during the second year. The proposed time scale is summarized in Figure 1.

TIME SCALE FOR SATELITE PROGRAM

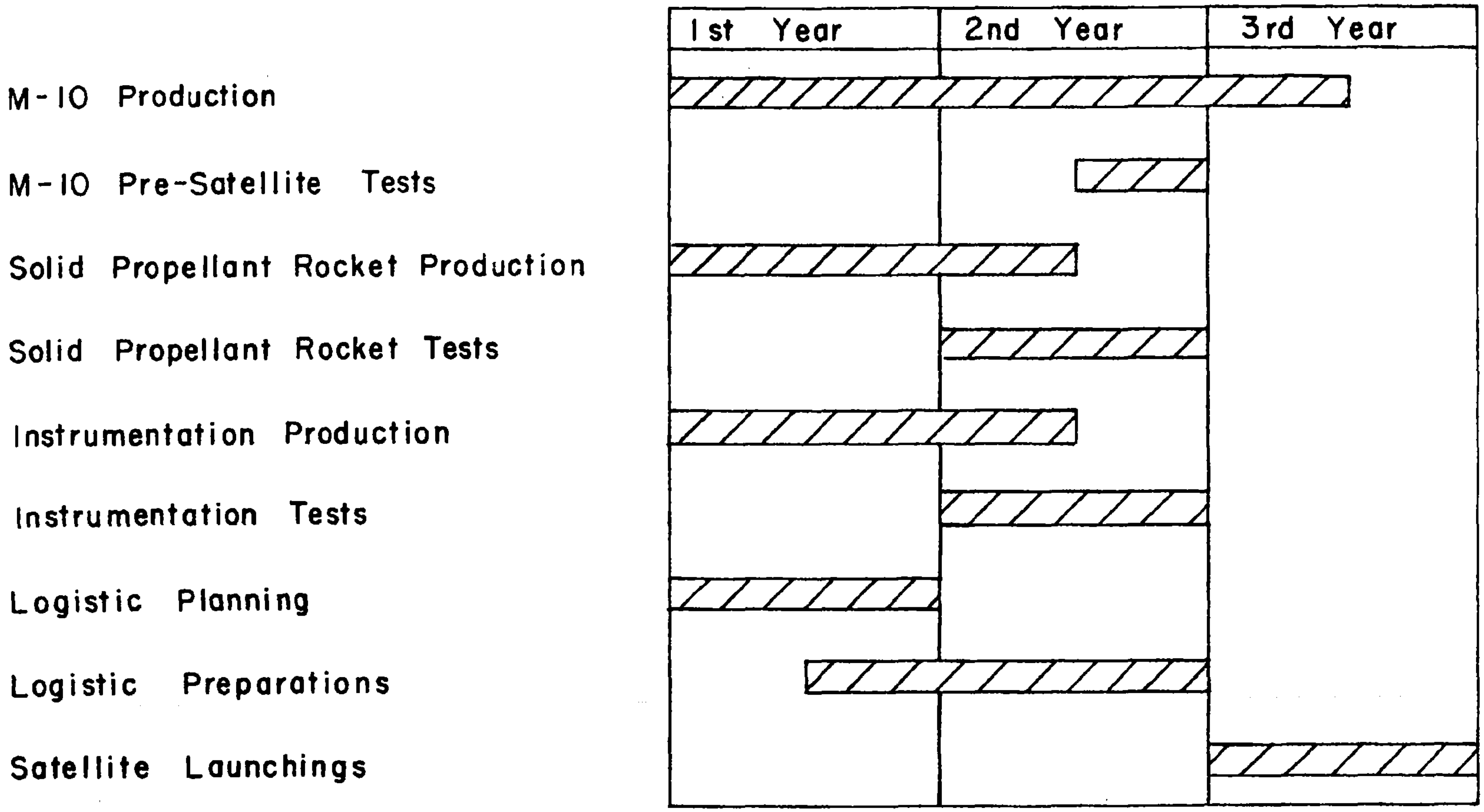

FIGURE - 1

At this time, the cost can only be broken down into major categories. The costs are based on Contractor's estimates and on experience in building instrumentation. The estimated costs, excluding logistic support, are:

Vehicle production	$5,000,000
Instrumentation	1,500,000
Contractor supplied field equipment and services	1,000,000
TOTAL	$7,500,000

Organization

The creation of even a small satellite is a project of sufficient magnitude to require an organization of broad scientific talent. Even the preparation of this report required advice from experts in materials, optics, electronics, astronomy, geophysics and geodetics. Although a specific approach has been presented here, it is not the only one that could be followed. Hence, in this section, it is proposed, at first, to take a broad view and to recommend several agencies as examples of those who might qualify for specific tasks.

1. Management and Logistic Support - All three services qualify, and it is likely that the combined efforts of at least two will be required.

2. System Contractor - A project of this type will require a continuing system analysis. Agencies suggested for this work are those which have broad scientific talent and, in addition, have handled at least one large rocket vehicle project. The Bell Telephone Laboratories, the Jet Propulsion Laboratory and the Naval Research Laboratory are in this category; Bell has had system responsibility for Nike, JPL for Corporal and NRL for Viking.

3. Geodetic Measurements - Four agencies are known to have experience in this field: the Army Map Service, the Coast and Geodetic Survey, the Naval Hydrographic Office, and the Naval Observatory. The geodetic information

in this report was prepared in cooperation with the Army Map Service.

4. Vehicle Contractors - No attempt is made to list the various contractors who have experience in rocket propulsion and airframe design. A sizeable number of industrial companies would qualify.

5. Instrumentation - The agency chosen for geodetic measurements would be the logical one to provide optical instrumentation. The radio system described in this report was designed by NRL. Other agencies known to have developed radio interferometer systems for missile tracking are the Convair Division of General Dynamics Corporation and the General Electric Company. With regard to geophysical measurements, the advice of the IGY committee could be sought. The Naval Research Laboratory has many years of experience in this field.

An organization capable of implementing the specific satellite proposed in this report is:

1. Management and logistic support - Tri-service
2. System contractor - Naval Research Laboratory
3. Geodetic measurements - Army Map Service
4. Vehicle contractors - The Glenn L. Martin Company
Atlantic Research Corporation
5. Radio tracking - Naval Research Laboratory
6. Geophysical measurements - Naval Research Laboratory